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U.S. NATIONAL WEATHER EXPERIMENT STORMFEST 1992: WAVE AND TURBULENCE IN FRONTAL ZONES

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ABSTRACT

A high density of surface and upper air observations, including aircraft observations, were accumulated during the STORM-FEST Experiment in the central United States (1 February-13 March 1992). These data are being analyzed to identify significant internal gravity wave and turbulent activity that occur in association with low-level frontal passages. The principal analysis method is local decomposition using wavelets as basis functions. These functions provide information on both scale and translation of coherent events, and are well-suited for frontal analyses. Dissipation of kinetic energy in frontal zones will be determined using data obtained during STORM-FEST. This information will be used in conjunction with theoretical modeling of the frontal scale contraction process that is currently poorly understood.

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STORM-FEST 1992: WAVES AND TURBULENCE IN FRONTAL ZONES
Report of Activities, 1 January–1 December 1992

1. Introduction

A principal goal of the U. S. Weather Research Experiment STORM-FEST Program is to investigate the structure and evolution of fronts and associated mesoscale phenomena. The goals of the present investigation are to participate in the STORM-FEST field program in the central United States, 1 February–13 March 1992, to analyze data collected during this field phase, and to construct models of frontal transition zone dynamics.

2. Boundary-layer observations

The present focus is to meet the stated goals by concentration on processes occurring in the boundary layer before, during, and after frontal passages. This effort requires the acquisition of data on spatial scales of meters to tens of kilometers, and on temporal scales of seconds to tens of minutes. The Principal Investigator, in conjunction with investigators at the University of Colorado, National Center for Atmospheric Research (NCAR and the Wave Propagation Laboratory of the National Oceanographic and Atmospheric Administration (NOAA), participated in the establishment of a dedicated boundary-layer array of instruments that collected data during the six-week observational period of STORM-FEST. This array, situated in northeastern Kansas, consisted of several surface mesonet stations (NCAR PAM II), radiosonde observations (CLASS), surface heat and momentum fluxes (NCAR ASTER), wind and temperature profiles (NOAA/WPL/LASS and RASS), and dual-Doppler radar coverage to provide wind circulations.

This network was supplemented by data acquisition from the NCAR King Air aircraft during frontal passages over, and close to, the boundary-layer array.

There were three or possibly four frontal passages through the boundary-layer array, accompanied by aircraft penetrations, that can be used to examine the boundary-layer response.

3. Grant activities during the first year

William Blumen (PI) and Nimal Gamage (Research Associate) spent, respectively, five and four weeks at the STORM-FEST Operations Center at Richards-Gebaur AFB, south of Kansas City. Participation in STORM-FEST operations included: Scientific Mission Planning Team direction of the daily operations, participation as a King Air flight scientist, and preliminary data acquisition and analysis of selected case studies.

Following the completion of the field phase in mid-March, research plans were developed to establish both short- and long-term goals. Prior to STORM-FEST, W. Blumen and N. Gamage had initiated a study of frontal events that passed the Boulder Atmospheric Observatory (BAO) 300 m tower, situated about 25 km east of Boulder, Colorado. The aim was to apply a relatively new objective analysis tool, wavelet analysis, to frontal data. Wavelets are a family of local functions that may be used to decompose a data record, just as trigonometric basis functions are used for Fourier decomposition. The former are, however, local basis functions that contain information about both translation and dilation of the events contained in the record; Fourier decomposition spans the whole domain and

is not suitable when the data are characterized by intermittent events and sharp gradients. It is just these types of events that are well-represented by wavelet analysis.

The NCAR King Air made three cross-frontal flights through the front that passed through the STORM-FEST boundary-layer array on the morning of 9 March 1992. These data were used in conjunction with data obtained by the BAO tower during two significant frontal passages. The analysis consisted of a detailed comparison of the advantages and limitations of wavelet, Fourier, and empirical orthogonal function decompositions of the same records. It was concluded that the wavelet analysis offers a space-scale decomposition that isolates rich local structures that accompany frontal passages. These local structures, such as internal gravity waves, within and near the frontal zone, and intermittent turbulent eddies are not adequately delineated by either Fourier or EOF analyses. This study has been completed and submitted for publication by Gamage and Blumen (1992).

4. Grant activities during the second year

Work has begun, and is expected to be completed during the next six months, on kinetic energy and enstrophy dissipation in fronts. This process is intimately related to an understanding of the dynamics that produce a characteristic limiting cross-frontal scale. The relative significance of either an inertial or a viscous control of the transition zone contraction process is at issue. Data from King Air flights and from the NCAR ASTER facility, in the boundary-layer array, will be used for this study.

Collaboration between University of Colorado, NCAR, and NOAA researchers to examine the diurnal evolution of the 9 March 1992 frontal passage has been initiated. This study will include data from three King Air flights as well as the full extent of data collected from all sources. Completion within one year is a goal.

Work to be carried out with a graduate student, to develop a boundary-layer model that takes account of frontal spatial and temporal inhomogeneities, is described in an AASERT proposal that will be submitted shortly.

5. Personnel supported

William Blumen (PI): March 1992

Nimal Gamage (Research Associate): 50 percent, 1992

Kevin Burks (Undergraduate Student Programmer): hourly, 1992

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6. Publications

Gamage, N. and W. Blumen, 1992: Comparative analysis of low-level cold fronts: wavelet, Fourier and empirical orthogonal function decompositions. *Mon. Wea. Rev.*, submitted.